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Characteristics of Large-Scale Antarctic Sea-Ice Dynamics from Satellite Microwave Radar Data

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Ocean-atmosphere exchanges are exaggerated when the Antarctic sea-ice cover is parted and the ocean exposed to brisk winds. Relative sea-ice motions and lead formation occur under tidal shear or conditions of high wind-stress divergence, and large resulting fluxes of sensible and latent heat cause rapid ice growth. Resulting production of cold salty shelf water participates in Antarctic bottom-water mass formation, and to some extent in driving horizontal and vertical theohaline circulation.

The majority of mixing and heat exchange in the ocean boundary layer is induced by momentum transfer to the sea ice surface during frequent storm bursts, and especially during the passage of fast-moving low pressure systems. Such noteworthy periods of dynamic-thermodynamic changes in the ice cover, however, are more often than not accompanied by a blanket of cloud due to atmospheric radiation-feedback mechanisms. In these cases, the atmosphere is inherently more electromagnetically opaque, and retrievals of ice characteristics informal ion using satellite passive microwave algorithms are called into question. Recent studies indicate that traditional ice concentration estimates can be in error by values exceeding 10% under typical storm conditions.

Microwave radar satellites, with wavelengths in the range 2-6 cm are the only other uninterrupted source of Weather-Independent Climate Images. Since 1991, an array of international satellites have been acquiring microwave radar data over the Southern Ocean sea-ice cover. The C-band Active Microwave instrument on board ERS, for instance has two modes; (a) Synthetic Aperture Radar (SAR) and (b) Scatterometer. Together, these combined microwave data enable uninterrupted imaging of this geographic region with (a) mesoscale coverage and high resolution (25m); or (b) and global coverage with medium-scale (~12 km) enhanced resolution. Together with the more recent additions of Ku-band data from the NSCAT scatterometer, and the C-band RADARSAT SAR, these combined radar datasets are now routinely used to measure ice kinematics and surface conditions in response to meteorological forcing.

Together, these new datasets yield a variety of important new information on the seasonal to interannual variability in ice dynamics, and the processes linking storms with mesoscale ice divergence. 3-day gridded motion fields are validated using buoy drift trajectories, and combinations of entire years of ice motion used to derive climatological mean ice motion around Antarctica. These data indicate a large interannual variability in both seasonal and mean annual drift, which in turn appear linked to climatic anomalies in sea-level pressure and meridional wind stress derived from ECMWF analysis fields. Similarly, periods of high wind-stress divergence result in openings of the ice cover and notably a brief reappearance of the winter Weddell Polynya in 1994, which was first discovered in the Scatterometer images.

Active microwave radar observations in the Southern Ocean are actively contributing towards revolutionizing the study of Antarctic sea-ice geophysics. Seasonal patterns of global sea-ice drift together with the accompanying transitions in sea-ice characteristics can now be well characterized. The longer these high-resolution satellite radar records become extended, the better the chances of measuring of climate-related timescales of Antarctic sea-ice variability.

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